

*This publication will not be
disposed of without authority of the
Chief Signal Officer.*

UNITED STATES SIGNAL SERVICE

MONTHLY WEATHER REVIEW.

VOL. XVI.

WASHINGTON CITY, JANUARY, 1888.

No. 1.

INTRODUCTION.

This REVIEW treats generally the meteorological conditions of the United States and Canada for January, 1888, and is based upon the reports of regular and voluntary observers of both countries. Descriptions of the storms that occurred over the north Atlantic Ocean are also given, and their paths shown on chart i, on which also appear the positions of icebergs and the limits of fog-belts west of the fortieth meridian. The weather over the north Atlantic was seasonable, and no storms of abnormal energy have been reported.

The month may be rated as an unusually cold one over the greater part of the United States, particularly on the Pacific coast, in the plateau region, and in all northern districts, the mean temperatures generally ranging from 6° to 12° below the normal. In the south Atlantic and Gulf states, and in the southern slope, the mean temperatures were normal or slightly above.

In connection with the temperature of the month, the remarkably cold weather in the northwestern states and territories, attending the prevalence of area of high pressure number iii, was an important feature. This extremely cold weather prevailed during the second decade of the month, and some of the minimum temperatures were the lowest recorded since the establishment of Signal Service stations. The minimum temperatures at many stations in the plateau region and on the Pacific coast during the decade mentioned, were similarly without precedent for that region.

The monthly precipitation was decidedly below the normal in Florida, the south Atlantic and east Gulf states, and largely in excess of the average in California. In other portions of the country it was nearly normal.

With this REVIEW is given an annual summary of temperature and rainfall for 1887, with two charts (numbers v and vi) showing, respectively, annual isotherms and departures from normal temperature, and annual precipitation.

In the preparation of this REVIEW the following data, received up to February 20, 1888, have been used, viz., the regular tri-daily weather-charts, containing data of simultaneous observations taken at 133 Signal Service stations and 23 Canadian stations, as telegraphed to this office; 176 monthly journals and 170 monthly means from the former and 23 monthly means from the latter; 307 monthly registers from voluntary observers; 56 monthly registers from United States Army post surgeons; marine records; international simultaneous observations; marine reports through the co-operation of the Hydrographic Office, United States Navy, and the "New York Herald Weather Service;" monthly weather reports from the local weather services of Alabama, Colorado, Illinois, Indiana, Kansas, Louisiana, Michigan, Mississippi, Missouri, New Jersey, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, and Tennessee, and the Central Pacific Railway Company; trustworthy newspaper extracts, and special reports.

ATMOSPHERIC PRESSURE (expressed in inches and hundredths).

The distribution of mean pressure for January, 1888, determined from the tri-daily telegraphic observations of the Signal Service, is shown by isobarometric lines on chart ii.

The mean pressure for January, 1888, is greatest in the upper Mississippi and Missouri valleys, and least in New England and the Maritime Provinces of Canada, there being a difference of 0.54 between the highest (Omaha, Nebr., 30.34) and lowest (Sydney, N. S., 29.80) monthly barometric means. From the upper Mississippi valley eastward the decline in the barometric means is gradual until reaching the seventy-fifth meridian; thence eastward the gradient is remarkably steep, the mean pressure ranging from 30.18, at Albany, N. Y., to 29.80 at Sydney, N. S. To the westward of the Missouri Valley the mean pressures first decrease to 30.1 over the middle Rocky Mountain slope; thence westward they increase to 30.25 in the northern and middle plateau districts, and from this region westward to the Pacific coast there is a sharp decline, the barometric means falling slightly below 30.0 on the north Pacific coast.

The contrast between the highest and lowest monthly mean pressures is worthy of special mention. The average difference between the highest and lowest barometric means for January for the territory embraced by the chart is about .35, and since

the establishment of Signal Service stations there has been but one year, viz., 1879, in which the range of mean pressure has equaled that of the current month.

The mean pressure of January, 1888, as compared with that for the preceding month shows an increase in all parts of the country, with the exception of the Canadian Maritime Provinces and the middle and south Pacific coast regions, in which districts there has been a slight decrease, ranging from .01 to .07. Throughout the region between the eighty-fifth and one hundred and second meridians the barometric means ranged from .15 to .24 higher than for the preceding month, the difference being greatest in the upper Mississippi and lower Missouri valleys.

The departures from the normal pressure at the various Signal Service stations are given in the table of miscellaneous meteorological data. In all parts of the country, with the exception of the northern and middle Pacific coast regions, the Canadian Maritime Provinces, and northern New England, the mean pressure for the month is above the normal, the departures exceeding .10 over an extensive area in the interior of the country, and amounting to .15 in the upper Mississippi valley. The stations reporting extreme departures above and below normal are respectively La Crosse, Wis., .17, and Roseburg, Oregon, .08.

BAROMETRIC RANGES.

The monthly barometric ranges at the various Signal Service stations are also given in the table of miscellaneous meteorological data. In the states bordering on the Atlantic coast the extreme ranges are .27 at Key West, Fla., to 1.98 at Eastport, Me.; between the eighty-fifth and one hundredth meridians, .69 at Mobile, Ala., New Orleans, La., and Pensacola, Fla., to 1.82 at Green Bay, Wis.; on the Pacific coast, .70 at San Diego, Cal., to 1.37 at Olympia and Tatoosh Island, Wash. In the south Atlantic states and extreme northwest the monthly ranges are slightly lower than normal for January, but in all other districts they are decidedly above the normal; the most marked departures occur over the region from the Missouri Valley westward to the Pacific coast, and from the Lake region eastward to the New England coast, where they exceed the normal from .25 to .75.

AREAS OF HIGH PRESSURE.

During the month of January six well-defined areas of high pressure were observed within the limits of territory covered by the tri-daily weather charts. All of these areas apparently descended from the northwest to the northern boundary of the United States, and the centres of all were first located between the one hundred and second and one hundred and seventeenth meridians. The general course of four of the areas was first in a direction south of east until between the fortieth and forty-fifth parallels, then to the north of east. The high area described below as the latter part of number iii moved first to the southwest until over the southwestern corner of Idaho, then to the southeast until near the Gulf of Mexico, after which it moved in an easterly direction. The area described as number vi moved first in a direction south of east until central over the north shore of Lake Superior, after which it crossed the states, moving almost directly south.

The following is a description of the areas of high pressure observed during the month, with the marked weather conditions prevailing during each:

I.—At 3 p. m. of the 3d an area of high pressure appeared to the north of Montana and, moving eastward, on the morning of the 5th covered the northern portion of the United States from Montana to New York, its centre remaining far to the north of Manitoba. This extension of high pressure to the eastward was accompanied during the 4th and on the morning of the 5th by light snows, with light winds, and at 10 p. m. of the 4th by a fall of from 20° to 30° in temperature over the northern and middle slopes of the Rocky Mountains. On the afternoon of the 5th the eastern portion of this area separated from the western portion and, with rapidly decreasing pressure, moved to the eastward and passed beyond the coast at midnight of the 6th. The western portion began to extend to the southeast, carrying with it a cold wave, during which the fall in temperature in twenty-four hours in the different districts affected by the wave ranged from 20° to 50°. This cold wave embraced the northern, middle, and southern slopes of the Rocky Mountains, the Missouri Valley, the upper Mississippi valley, and the southern part of the Ohio Valley and Tennessee, and caused a decided fall in temperature along the Gulf coast. On the morning of the 8th all of the United States west of the eighty-seventh meridian was covered by the area. Its centre was located just north of Montana from midnight of the 6th to the afternoon of the 8th, when again the area divided; one portion, attended by a still further fall in temperature, moving to the southeast with rapidly decreasing pressure, disappeared over Kansas after the 3 p. m. observation of the 9th; the other portion, moving to the southwest, assumed a position over Idaho, where it remained, with slight changes of position and increasing pressure, until the afternoon of the 9th, when the pressure, which had reached a height of 31.00 at Boise City, began to decrease, and at midnight of the 11th the area had disappeared.

From the 6th to the 12th low temperatures were experienced throughout California. Killing frosts occurred, and ice formed in some places to the thickness of four inches.

The following are extracts from the daily journals of regular Signal Service stations in California:

Red Bluff, 6th: killing frost formed on the roof to the depth of one-half inch. 8th, lowest temperature since 1888, 19°.8; killing frost. Sacramento, 7th: clear and cold, with killing frost; ice formed four-tenths of an inch thick on water in a tub on the roof. 8th, clear and cold, with an unusually heavy, killing frost; ice formed one-half inch thick; outside water pipes frozen up until sometime in the afternoon. 9th, clear and cold, with unusually heavy, killing frost, which remained on the ground all day in unexposed places; water pipes still frozen up. 10th, 11th, and 12th, clear, with killing frost; water pipes frozen up.

San Francisco, 6th: killing frost and ice visible this morning; continued clear throughout the day. 7th, killing frost and ice; continued cold and clear during the night. 8th, killing frost and ice, remained unmelted throughout the day in places partly sheltered. 9th, killing frost and ice this morning. The weather remained clear, not a cloud being visible during the day. The snow had disappeared from Mount Tamalpais, but some still remained on Mount Diablo and Hamilton and about the foothills east of station. 10th, ice observed this morning, but no frost. 11th and 12th, ice and frost observed.

Fresno, 6th: cold, raw day; killing frost. 7th, killing frost; the heaviest the observer ever saw in the valley; it was three-sixteenths of an inch deep, and roofs looked as though covered with snow; at 11 a. m. dense fog formed, and cleared away at 6 p. m., coming on again at 11.30 p. m. 8th, coldest day of the winter; oldest inhabitants say this is the coldest day ever known in the valley; observer went out among the orange groves, which do not seem to be injured by frost or cold; ice formed one-fourth of an inch thick, and the ground is frozen quite hard; 9th, 10th, 11th, and 12th, killing frost.

Los Angeles, 7th: a clear and cold day. Heavy frost and ice formed this morning. The mud in many of the streets froze, and pools of water were covered with a skim of ice. The mountain ranges visible to-day are heavily covered with snow nearly to the base. While no damage is reported to the fruit crop, fears are entertained for the safety of the oranges, especially should the cold continue. 8th, heavy frost and ice formed this morning. In some localities the ice was three-fourths of an inch thick, and remained unmelted all day in northern exposures. The mud in the streets and the surface earth froze in many places. Flowers in many places were damaged. No damage is yet reported to the oranges. 10th, very cold this morning; minimum temperature, 30°.9, the lowest recorded at the station since February 6, 1888, when it was 28°. Heavy frost and ice formed, and the ground froze in many localities. Vegetable gardens suffered seriously from the extreme cold of the past few days.

San Diego, 7th: light frost this morning, the first since August, but did not injure vegetation. 8th, very cool weather; minimum temperature down to 38°. A thin film of ice formed on shallow pools of water in the streets and a light frost was visible in the early morning; mountains covered with snow. 9th, light frost and ice appeared on the streets this morning. 10th, very cool, with light frost this morning. In the Cajon Valley the temperature was reported at 22° at sunrise yesterday morning.

II.—This area first appeared on the afternoon chart of the 10th. It was very elongated toward the southeast. At the succeeding observation it had extended to the Gulf of Mexico and its centre was located to the north of Dakota. From this position it moved to the southeast, with increasing pressure, until the afternoon of the 11th, after which it moved in an easterly direction and passed off the coast of Nova Scotia on the morning of the 13th. It was attended throughout its entire course by fair weather and light winds, except on the New England and middle Atlantic coasts, where northwesterly gales prevailed during the 11th. The fall in temperature ranged from 10° to 20°, the latter occurring in only a few instances.

III.—On the morning chart of the 12th an area of high pressure appeared to the north of Montana. On this chart was also shown a well-defined area of low pressure central near Cheyenne, Wyo., the subsequent course of which was to the southeast till central near Concordia, Kan., at 3 p. m., then rapidly to the northeast. At 10 p. m. of the 12th the area of high pressure had extended to the southeast over Montana, Dakota, and Nebraska, while the pressure at its centre had increased to 30.9, the centre of the area of low pressure before mentioned being located near La Crosse, Wis., and bounded by an isobar of 29.6, there being a difference of pressure of 1.3 between the centres of the two areas, separated by about 1,200 miles. This marked difference in pressure caused winds of from thirty to fifty miles an hour, accompanied, at some stations in Montana, Dakota, and Nebraska, by snow, which, with a fall of from 30° to 60° in temperature during the twenty-four hours preceding the 10 p. m. observation of the 12th, helped to make a violent storm in which many lives were lost and large numbers of cattle perished.

On the morning of the 13th the area had spread still farther to the southeast over Iowa, Missouri, and Kansas, carrying the cold wave with it, but with somewhat diminished intensity. At midnight it had extended more to the northeast, in rear of the area of low pressure referred to above, carrying with it the intensely cold wave, during which the fall in temperature in twenty-four hours was from 30° to 50° over Minnesota, Wisconsin, Illinois, Indiana, and western Michigan. At the 7 a. m. observation of the 14th the area had extended to the Atlantic coast over New England and the middle Atlantic states, but the cold wave was greatly diminished in intensity.

The following extracts from the daily journals of regular Signal Service stations are given to show the progress and intensity of this cold wave:

Fort Assinaboine, Mont., 11th: rapidly falling barometer and rising temperature. The wind changed from the northwest to southwest at 8.30 p. m., bringing a warm, "chinook" wind, when suddenly at 7.45 p. m. it changed its direction to northwest. High winds blew for two hours. A gale of forty-eight miles, north, was registered at 8.55 p. m., continuing forty-five minutes. A great amount of electricity was present in the air. 12th, rapidly rising barometer and a sudden fall in temperature. Brisk winds all day from the north.

Helena, Mont., 12th: at 2.30 a. m. the exposed thermometer read 38°, with wind veering to the northwest. Between this time and the 7 a. m. observation the maximum thermometer indicated a temperature of 40° 5', and the minimum registered was -9° 0', making a fall of 49° 5' in four hours and thirty minutes. At 10 p. m. the minimum thermometer registered -26° 0', making a total fall of 66° 5' in less than twenty-four hours.

Poplar River, Mont., 11th: growing warmer at 11 a. m.; falling barometer. 12th, colder, high northwest wind; snow all blown into drifts and temperature -22° and falling.

Fort Custer, Mont., 11th: clear and pleasant weather. 12th, colder, cloudy weather. Light snow began during night and ended at 7.27 a. m. The snow was accompanied by high northerly winds which began at 2.42 a. m. and ended 9.30 a. m., with maximum velocity of forty-nine miles. This storm, commonly known as a "blizzard," was the severest of the season. No lives in this immediate vicinity are reported to have been lost. Travel on the Northern Pacific is completely blocked, owing to the drifting snow and intense cold. Solar halo, with contact arch, visible nearly all day.

Bismarck, Dak., 11th: rapidly falling barometer and rapidly rising temperature; high east winds, veering to southeast. 12th, order to hoist cold-wave signal received 1.20 p. m.; northwest gale began at 6.30 a. m. and continued all day; highest velocity, fifty-four miles, northwest. The wind shifted to northwest at 6 a. m., increasing in force, drifting the snow which had already fallen and that which was falling to depths of five to twenty feet. This, with rapidly falling temperature, constituted a well-defined "blizzard;" trains on the Northern Pacific Railroad are delayed and travel in small conveyances suspended. 14th, cold-wave signal lowered 12.15 p. m.; minimum temperature, -37°.

Fort Totten, Dak., 11th: fall in barometer, rise in temperature, wind north, changed to south and blew a gale, velocity fifty-two miles per hour at 11 p. m.; temperature continued to rise till midnight. 12th, rising barometer, wind southeast, changed to north at 7.45 a. m., and blew a gale during the day; cold wave signal ordered up at 1 p. m.; minimum temperature -26°; trains stopped.

Saint Vincent, Minn., 12th: low barometer, rising rapidly; gale ended at 5.25 a. m.; maximum velocity thirty-six miles south; cold-wave signal ordered up at 12.30 p. m.; at 1 p. m. a "blizzard" struck here; beginning at 2.40 p. m. the wind blew a terrific gale, attaining a velocity of from thirty-six to forty-eight miles from 8 p. m. to 2 a. m. of the 13th; cold-wave signal lowered at 7 a. m.; maximum temperature 2°, minimum temperature -40°. The display of cold-wave signals occasioned considerable favorable comment.

Huron, Dak., 12th: the southerly gale of yesterday and last night continued, with light snow, until 6 a. m., when the gale began to abate; at 12 m. its velocity was twenty-four miles per hour; between 12.35 and 12.40 a. m. it had subsided to twelve miles, with a light snow and damp atmosphere, the sky being obscured in patches by nimbus clouds; at 12.42 p. m. the air was perfectly calm for about one minute; the next minute the sky was completely overcast by heavy black clouds which, for a few minutes previous, had hung along the western and northwestern horizon, and the wind veered to the west and blew with such violence as to render the position of the observer on the roof unsafe. The air was immediately filled with snow as fine as sifted flour. The wind veered to the northeast, then backed to the northwest in a gale which, in three minutes, attained a velocity of forty miles an hour. These conditions continued steadily all day and till 4 a. m. of the 13th, when the gale began to abate and the snow soon after ceased. Cold-wave signals hoisted at 2.35 p. m. At noon the temperature was 20°, and at 10 p. m. -17°, and fell to -28° during the night. The wind averaged from forty-five to fifty miles, and attained an extreme velocity of sixty miles per hour. The number of lives lost in this (Beadle) county is eleven, and a considerable number injured.

Moorhead, Minn., 12th: wind during the early a. m. and forenoon extremely violent; maximum velocity fifty miles, south. Cold-wave order received 1.80 p. m. There was a sudden change of wind from south to north at

1.45 p. m. Heavy, blinding snow at intervals. 14th, cold-wave signal display terminated. Maximum temperature during display, 12°, minimum temperature, -32°; range of temperature, 44°.

Yankton, Dak., 12th: at about 2.30 p. m. the wind suddenly changed from south to north, blowing with increasing violence and accompanied by snow. The temperature fell rapidly, and the worst "blizzard" known in this region for years set in. Cold-wave signal received 4.30 p. m.

Crete, Nebr., 12th: light, moist snow commenced in the early morning, and at 9 o'clock heavy snow was falling, which continued till 4.30 p. m. Cold-wave signal hoisted 1.30 p. m. There was but little wind, and the temperature ranged from 25° to 30°. At 4.10 p. m. the wind suddenly sprang into a gale, shifting from south to northwest. The temperature fell 18° in less than three minutes. The snow drifted so badly as to render all travel extremely difficult and dangerous.

North Platte, Nebr., 12th: barometer fell rapidly during the night until 9 a. m., when it commenced to rise. Light snow, accompanied by southwest wind, began falling during the night and ended at 9 a. m. Hoist cold-wave signal received 1.20 p. m. Wind changed from south to the northwest, attaining a velocity of forty miles at 8 p. m. Temperature fell 32° in thirteen hours. 14th, lowered cold-wave signal 1 a. m. Justified. Maximum temperature during display, 4°; minimum temperature, -26°.

Topeka, Kans., 12th: barometer fell rapidly till after 3 p. m., with brisk southerly winds and rising temperature. At 6.34 p. m. the wind, without warning, veered to the northwest and instantly increased from twenty-four miles per hour to sixty-six miles per hour; gradually diminishing in force, it was still forty-two miles at 10 p. m. Clouds soon cleared after 7 p. m. From 6 to 10 p. m. the temperature fell from 34° to 2°.

Omaha, Nebr., 12th: light southeast wind prevailed during early part of the day and up to 5.17 p. m., when it suddenly shifted to northwest and instantly increased to thirty miles; at the same time the temperature began falling rapidly; at 8 p. m. was 27°, and at 10 p. m. -6°, showing a fall of 33° in seven hours. Order to hoist cold-wave signal received 1.40 p. m.

Cheyenne, Wyo., 12th: maximum wind of sixty miles, northwest, at 7.53 p. m. 13th, snow began at 4.15 p. m. The temperature fell from 14° at 3 p. m. to -10° at 5 p. m., and to a minimum of -20° during the night.

Denver, Colo., 12th: very high wind during the day, reaching a velocity of sixty miles per hour, north, at 8.30 p. m. Instrument shelter was blown down, tearing some of the roof with it. Hoist cold-wave signal received 7.32 p. m. Temperature when hoisted, 28°. 13th, high wind in the afternoon, reaching a velocity of thirty miles, north, at 4.05 p. m. Cold-wave signal lowered at 10 p. m. Cold-wave warning was not only justified but was followed by one of the most severe cold waves that ever struck this section.

The postmaster at Lisbon, Dak., reports as follows concerning this storm: "The thermometer on January 11th stood at 10° above zero; the wind, with a blinding snow storm, came from the south; velocity about thirty miles per hour. At 11 a. m., same day, the wind changed to the north; the thermometer went to zero; the wind continued at thirty miles per hour until 11 p. m., at which time it blew at least forty miles per hour, and the snow flew so one could not see across the street when a bright light was burning. At daylight January 12th, the wind was still blowing very hard, and the thermometer registered 18° below zero. This morning, January 13th, 7 a. m., the thermometer is 35° below zero; wind still from the north and getting colder."

Keokuk, Iowa, 12th: cold-wave signal hoisted 7.80 p. m., temperature then 80°. 13th, wind veered to the west at midnight, blowing a gale of thirty-six miles per hour at 12.15 a. m.; temperature fell rapidly, and at 8 a. m. had fallen 55° in eight hours. 14th, cold wave signal lowered at 7 a. m.; range of temperature during display was from 45° to -13°.

Des Moines, Iowa, 12th: order to hoist cold-wave signal received 7.55 p. m. 13th, the high wind of last night continued until 6 a. m. to-day, causing immense snow drifts in railroad cuts; range of temperature in sixteen hours ending 7 a. m. 42°.

Saint Paul, Minn., 12th: light to moderately heavy snow began 10.15 a. m. and ended 11.35 p. m.; snow drifted very badly; cold-wave signal hoisted 6.50 p. m. 13th, very cold, fresh to brisk northwest winds, diminishing in force in the afternoon. Railway trains over the roads extending in every direction from here, except the Wisconsin Central to Chicago and the short line trains from here to Minneapolis, neither arrived nor departed during the day. 14th, cold-wave signal lowered at 7 a. m.; display justified; maximum temperature during display, 12°; minimum temperature, -24°.

La Crosse, Wis., 12th: order to hoist cold-wave signal received 8 p. m. 13th: light snow ended during the night; wind increased in velocity from the west and temperature fell from 19° to -6° in a. m. and continued to fall rapidly until after 10 p. m. when it reached -20°. 14th, cold-wave signal down; justified; maximum temperature, 19°, after 10 p. m. of the 12th; minimum this morning, -22°, a fall of 41° in thirty-one hours.

The "blizzard" was most destructive in its effects in middle and southern Dakota, which is probably due to the fact that it came upon that section of the territory between 10 a. m. and dark, when many people would naturally have been away from shelter, as the weather previous to that time was warm and pleasant. The loss of life as given in newspaper accounts has been doubtless exaggerated, but was evidently greater than in any previous storm, owing to the extensive settlement of the country in the last few years. The change in direction of wind

and fall in temperature were more sudden than is usual, but the most violent part of the storm was of short duration, not lasting longer than thirty-six hours at any place, and, at some places, less than twenty-four hours. Some Dakota storms in previous years have been more severe, especially the storm of January 7th to 10th, 1873.

On the afternoon of the 14th the extension of high pressure was more to the southwest and the middle and southern slopes were visited by a severe cold wave, accompanied by light snow, during which the fall in temperature was from 30° to 50° in twenty-four hours. On the morning of the 15th the whole of the United States was covered by this high area, which was dividing into two portions, one remaining still central over Idaho, the other central over Kansas. The cold wave had moved to the southeast over the west Gulf states and freezing temperatures were reported from San Antonio, Galveston, Corpus Christi, Rio Grande City, Brownsville, Tex., and Shreveport, La. From its position over Kansas the eastern portion of this area moved to the northeast, and, with slowly diminishing pressure, passed beyond the coast at 3 p. m. of the 17th. The cold wave, accompanied by snow, excepting along the Gulf coast where rain fell, advanced during the 15th and 16th over the eastern Gulf states, Tennessee, and the south Atlantic states.

The following extracts from daily journals of regular Signal Service stations are given to show the intensity of the cold wave over the southern slope of the Rocky Mountains and the west Gulf states:

Fort Elliott, Tex., 14th: "norther" struck the station at 3 a. m. Light snow began 6.40 a. m., ended 8.30 a. m.; cloudy weather; mean temperature of the day, -7°, the coldest day on record. Rapidly rising barometer, with very high wind; maximum velocity forty-eight, north. 15th, "norther" continues. Coldest temperature since the establishment of station, -14°, this a. m.; gale forty miles, north. Cloudy during day, clear at night.

Abilene, Tex., 14th: pleasant weather during the early part of forenoon. A brisk "norther" began blowing at about 10 a. m., with the temperature falling rapidly. At 10 p. m. the minimum temperature recorded was 2° below zero. Light, dry snow began 10.50 a. m., and continued. Order to continue cold-wave signal received at 2.50 p. m. 15th, at 7 a. m. the minimum thermometer registered 5° below zero, which is the coldest of which there is any record, and colder than the oldest residents have ever seen it.

Galveston, Tex., 15th: the wind shifted to northwest at 1 a. m., and soon reached the velocity of a storm. It was attended by light rain, which changed to snow at 4 a. m. A veritable "blizzard" is raging in Galveston to-day. The temperature is below freezing, the wind blowing at the rate of from thirty-six to forty miles an hour, with fine snow, or frozen mist, which cuts like drifting sand. The wind moderated somewhat during the afternoon and night. Every object out of doors coated with ice an inch thick.

Corpus Christi, Tex., 15th: a severe "norther" reached the station at 2 a. m., and the wind increased to a velocity of from thirty to thirty-six miles. The temperature fell rapidly from 60° at 2 a. m. to 16° at 10 a. m. The minimum temperature, 16°, was not reached until 7 p. m. A small fishing sloop was sunk in the bay near the station. Much suffering was caused by the extreme and sudden change in temperature.

Rio Grande City, Tex., 15th: terrific "norther" came on at 5.45 a. m., with rain, freezing as soon as fallen. Temperature fell 37° from 10 p. m. 14th to time storm came on, most of which occurred within a half hour. 16th, "norther" continues. All small receptacles filled with water froze solidly. General suffering and sickness among the Mexican inhabitants.

Brownsville, Tex., 15th: sudden change in pressure and temperature; minimum temperature, 23°; wind freshened at 7 a. m., increasing to high (thirty-four miles) at 11 p. m.; light rain began during the night, changing to snow and sleet at 9 a. m. 16th, severe "norther"; minimum temperature, 21°.4; light sleet ended at 9 a. m.; trees, houses, and fences covered with ice an inch thick; coldest weather since December 31, 1880, and January 1, 1881, when minimum temperature was 18°. 17th, very light rain from 7.30 a. m. all day; slightly warmer; ice melting rapidly; not much damage to crops from storm of 15th and 16th, but cattle and people suffered greatly.

Vicksburg, Miss., 15th: hoist cold-wave signal received 7.20 a. m.; light rain began in the early morning, changed to sleet at 10 a. m. and ended 2.37 p. m. 16th, cold-wave signal lowered at 7 a. m.; the signal was justified, the temperature falling from 37° to 17° during the display.

The western portion of the high area which was central over Idaho on the morning of the 15th remained in that position until the morning of the 18th, when it was central over Colorado and Utah, with central pressure 31.06 reported from Montrose, Colo. From this position it continued to move to the southeast until near the Gulf coast of Texas, then in an

easterly direction until it passed off the coast of Georgia on the morning of the 20th. It was accompanied throughout its course from Colorado to the Atlantic by fair weather and slightly higher temperature, except on the coast of the east Gulf states, where it caused a limited cold wave on the 18th.

Unusually low temperatures were observed throughout California from the 14th to the 18th, and frost and ice were formed at places where they are of very rare occurrence.

The following extract from the daily journals of regular Signal Service stations in California will describe the unusually cold weather which prevailed:

Red Bluff, 14th: clear weather, with high northwest wind; minimum temperature, 18°, the lowest since the establishment of the station. 16th, light snow fell from 5 to 5.35 p. m., melting as soon as it reached the ground. 17th, a killing frost was observed this morning. 18th, a light frost this morning.

Sacramento, 14th: high northerly winds, clear and cold; minimum temperature this morning is the lowest recorded by the Signal Service at this station since July 1, 1877, and the coldest known since January 21, 1864, when Dr. Logan recorded 19°, which is the same as the minimum of to-day. Ice on water in a tub on the roof measured 1.1 inches in the centre of the tub. The average temperature to-day is 28°, and ice was forming all day in the shade. Slush ice was floating down the Sacramento River, the first time since 1864 that such a thing has happened. 15th, clear and cold, minimum temperature being the same as yesterday. On a small pond back of the railroad company's roundhouse, ice was thick enough to bear a man weighing one hundred and eighty pounds, and boys were skating upon it. 16th, clear and cold; killing frost observed in the morning; ice on the roof is three inches thick; boys are still skating on the pond. 17th, clear and cold, with killing frost; China Slough partially frozen over. 18th, killing frost.

San Francisco, 14th: weather continued clear and cold throughout the day, not a cloud being visible; the wind attained a velocity of forty miles per hour in the early morning, doing considerable damage to shipping and wharves in the northern section of city front; a pile-driver, valued at \$4,000, was capsized in Mission Bay; a number of vessels in different parts of the harbor parted their lines and coming into collision were damaged to some extent; water pipes were frozen in various parts of the city; ice in the gutters this morning was fully .5 of an inch in thickness. 15th, water in pipes frozen this morning, resulting in the usual damage by bursting; this is a thing of very rare occurrence in this city; the minimum thermometer read 29° this morning; being 4° lower than any previous record since the establishment of the station in 1871; the bottle of water kept in the instrument shelter was frozen solidly and did not thaw out until after 3 p. m.; ice was seen this morning fully 4 inches in thickness. 16th, light snow began falling at 10.20 p. m. and continued till 11.40 p. m., at which time it was 0.1 inch deep. 17th, snow remained unmelted in the western part of the city until after 3 p. m.

Fresno, 14th: no frost was visible as on other mornings but the ground was frozen hard. Orange growers in the country say it is the worst weather ever experienced here, but they do not think oranges are injured; a personal inspection of those in town shows no damage. Old residents say that nothing like this winter was ever known in the valley. 15th and 16th, killing frosts. 17th, water pipes in the building froze and burst; heavy frost in the morning; a light fog from 11 a. m. to 11.40 a. m. froze on the trees, presenting a beautiful appearance. 18th, killing frost.

San Diego, 17th: light frost this morning, also a thin film of ice on shallow pools of water on the street; no damage done to vegetation.

Los Angeles, 15th: minimum temperature 32°; heavy frost and ice formed this morning. The observer was informed by a gentleman from this building who was duck-shooting at Balona, on the coast near Santa Monica, that ice formed on the sloughs thick enough to bear the weight of a small dog he had with him, and the ice remained till near mid-day before melting. 16th, very cold this morning, minimum temperature 31°; heavy frost and ice formed; water pipes in many places froze solid. An eastern mail arrived to-day, the first received for a week, on account of the trains having been blocked by snow in the mountains. 17th, light frost formed this morning.

IV.—The 7 a. m. chart of the 18th shows an area of high pressure advancing from the northwest over Montana and Dakota. It was central north of Montana from 10 p. m. of the 18th to 7 a. m. of the 20th, at which time it had extended to the southeast over the northern slope, the Missouri, and upper Mississippi valleys, and attended by fair weather, light winds, and a cold wave, the fall in temperature ranging from 20° to 40°. Its centre moved to the southeast until over southern Minnesota, then in a direction north of east until north of Lake Ontario, after which it moved south of east, with rapidly decreasing pressure, until it passed off the New Jersey coast on the afternoon of the 22d. It was accompanied throughout its course by generally fair weather. At midnight of the 20th the cold wave had extended southward over the middle and southern slopes of the Rocky Mountains. As the cold wave moved eastward it became very much diminished in intensity and

caused a fall of only 10° over the Lakes, the Ohio Valley, and the middle Atlantic states.

V.—On the morning of the 22d an area of high pressure began to appear to the northeast of Montana. It moved to the eastward, gradually extending to the southward, until in the afternoon of the 23d its centre was located in northeast Dakota, and the isobar of 30.3 included nearly all that portion of the United States between the eighty-second and one hundred and seventh meridians. From this position the area moved first to the southeast and afterwards to the eastward, keeping near the forty-fifth parallel, maintaining the maximum pressure, 30.6, until midnight of the 24th, when the pressure began to decrease, and it passed off the coast of New Brunswick at midnight of the 25th, when the pressure was but .01 above the normal. It was accompanied by light winds and generally fair weather, the temperature falling not more than 15° .

VI.—This disturbance was first noticed on the afternoon of the 26th to the north of Dakota. It extended to the southeast until at midnight of the 27th its centre, with pressure 30.6, was located over western Lake Superior, and the area extended to the Gulf of Mexico. From this position it began to move rapidly southward, with decreasing energy, and on the morning of the 29th it passed off the coast of Florida, the central pressure bounded by an isobar of 30.2, scarcely above the normal. This area was attended by fair weather, light winds, and only a slight fall in temperature, excepting over the Lakes and the Ohio Valley, where light snows occurred during the 27th, caused by the influence of a very active area of low pressure then to the northeast.

AREAS OF LOW PRESSURE.

Ten areas of low pressure have been traced during January over the territory occupied by stations of observation. Of this number, one is a continuation from December; five were first observed to the west of the Rocky Mountains; two originated in the territory to the north of Montana and Dakota; and two developed in the central valleys east of the ninetieth meridian. The average rate of movement of these depressions was 39.4 miles per hour, the general velocity of each depression ranging from 28.1 to 54.4 miles per hour.

The following table shows the latitude and longitude in which each area was first and last observed, and the average velocity in miles per hour:

Number of area.	First observed.		Last observed.		Average hourly velocity.
	Lat. N.	Long. W.	Lat. N.	Long. W.	
I.....	44 00	123 45	46 20	84 30	28.1
II.....	48 50	118 20	39 40	93 15	50.0
III.....	43 00	124 30	32 45	104 00	28.1
IV.....	41 00	91 30	47 50	71 30	42.5
V.....	50 45	111 00	47 20	78 00	46.9
VI.....	48 50	119 30	31 50	106 20	31.7
VII.....	40 00	87 00	43 45	64 30	36.5
VIII.....	47 35	123 50	47 30	65 00	33.3
IX.....	48 20	125 00	41 35	93 45	54.4
X.....	51 45	96 40	37 00	77 20	42.0

Average rate of progress, 39.4 miles per hour.

I.—This area of low pressure is a continuation of number xi of the preceding month. On the morning chart of the 1st it is shown to be central near Escanaba, Mich., where the pressure was 29.22. It was attended by severe gales and snow over the Lakes on the morning of the 1st. Snow was also general in the interior of the New England and middle Atlantic states, and heavy rains occurred along the coast, where south to west gales prevailed on the 1st and 2d. Heavy rains occurred in Tennessee, Georgia, and Alabama. The area passed to the northeast beyond the region of observation during the succeeding twenty-four hours.

The following notes from Signal Service observers will show the severity of this storm:

Wash Woods, N. C., 1st: heavy surf; at 4.50 p. m. the bark "Ada Gray" went ashore near Little Island Life-Saving station. Crew of eleven men saved.

Atlantic City, N. J., 1st: warmer, with rain from early a. m. to 9 p. m., fol-

lowed by dense fog during the night. Storm southeast signal changed to storm northwest signal at 7.30 p. m. Southeast gale from 12.22 p. m. till 8.20 p. m., maximum velocity, thirty-six miles. Wind veered to the northwest in the evening, and decreased in force.

New London, Conn., 1st: the light snow which began on the 31st changed to rain at 2.30 a. m., and the snow on the ground was all melted before daylight. The rain continued incessantly during the entire day, and was quite heavy at 7 p. m. The total amount in twenty-four hours was 2.27 inches. The wind was high from the southeast, veering to south. Gale begun 11 a. m. and continued till after midnight. The maximum velocity was forty miles per hour, at 6.30 p. m. Several vessels sought shelter in the harbor, but no damage was reported in this vicinity. The temperature is unusually high.

Narragansett Pier, R. I., 1st: light rain and southeast gale. Schooner "Mary A. Drury" ashore at Point Judith; fast going to pieces; will be a total loss. 2d, three masted schooner "Wm. H. Jordan," coal, from Baltimore for Bristol, R. I., struck on the rocks southwest side Block Island at 4.26 a. m. and sunk; crew took to rigging, and were rescued by Life-Saving crew.

Block Island, R. I., 1st: brisk and high southeast to southwest winds; temperature rose from 29° to 55° .

Eastport, Me., 2d: light rain changed to heavy at 12.10 a. m. and ended at 10.30 a. m. Order to hoist storm and southeast signal received 12.25 a. m. Gale began 4.03 a. m. and ended 5.10 a. m. Maximum velocity, thirty-six miles, from the south. No disasters reported.

II.—On the morning of the 1st this area of low pressure was central over Washington Territory, with lowest pressure, 29.68, at Spokane Falls. From this position it moved to the northeast, and at the succeeding observation was central north of Montana, the central pressure having declined to 29.4. It afterwards moved in a southeasterly direction and disappeared over the lower Missouri valley after 3 p. m. of the 2d by a gradual increase of pressure. It was attended by generally fair weather and increased temperature, which was very marked over the northern and middle slopes of the Rocky Mountains at midnight of the 1st and morning of the 2d, the change amounting to 40° in twenty-four hours.

III.—This area of low pressure first began to appear off the north Pacific coast at 3 p. m. of the 2d. It moved in a direction slightly south of east until midnight of the 3d, when it was central over Colorado, with lowest pressure bounded by the isobar of 29.4. From this position its centre moved back and forth from central Colorado to western Utah until the morning of the 6th, when it took a southeast course and disappeared, by a gradual increase of pressure, at midnight of the 6th over the southeast corner of New Mexico. It was accompanied by heavy rains on the 2d and 3d over the middle and south Pacific coast regions, light rains over the middle and southern plateaus on the 4th and 5th, and by light snows over the northern slope of the Rocky Mountains and the Missouri and upper Mississippi valleys on the 4th, 5th, and 6th.

IV.—This area of low pressure is apparently a portion of the preceding area which was detached on the night of the 5th by an area of high pressure then bearing down from the northwest. It was central over Indiana and Illinois during the 6th, after which it moved rapidly to the northeast and disappeared beyond the region of observation on the afternoon of the 7th. Precipitation was general over the upper Mississippi valley, the Ohio Valley, and the Lakes on the 6th and 7th, and over the New England and middle Atlantic states during the 7th.

V.—On the morning of the 11th a low pressure area was advancing over Montana from the northwest, and at the succeeding observation its centre was located to the north of Fort Assinaboine. It moved in a southeasterly direction until the morning of the 12th, when it was central near Cheyenne, Wyo., when the pressure was 29.44. The area was, in shape, an elongated ellipse, the major axis being north and south, and it covered all that portion of the United States between the ninety-second and one hundred and seventh meridians. Throughout this region snow prevailed, excepting in the southern portion of Texas, where rain occurred. In the eastern quadrants the wind blew from the south and southeast at a rate of from twenty to forty miles per hour, while in the western quadrants the wind blew from north to west with still greater force. During the 11th the temperature had risen throughout this area from 10° in the southern portion to 40° in the northern portion, but was still below zero in the extreme northwest and

near the freezing point in the middle and southern sections. At 3 p. m. of the 12th the storm was central near Omaha, Nebr., from which position it moved to the northeast and passed to the north of the region of observation after 3 p. m. of the 13th. As the storm advanced, with rising temperature and south to east winds in the eastern quadrants, the wind suddenly shifted to the northwest and blew with increased velocity in the western quadrants, while the temperature in the rear of the storm suddenly fell from 30° to 50°, which intensely cold wave accompanied an area of high pressure then advancing from the northwest.

VI.—This disturbance was observed moving from the north Pacific eastward, and was central over Washington Territory on the morning of the 12th. It moved to the southeast till central over Colorado, then to the south, and was last observed in southern New Mexico on the 14th. It was attended by light rains in the north Pacific region on the 12th and 13th.

VII.—This low pressure area apparently developed in the Ohio Valley on the morning of the 17th. The central pressure was bounded by an isobar of 30.4. It moved to the northeast with decreasing pressure until north of Lake Ontario, then to the southeast, passing off the coast of Massachusetts on the morning of the 18th, with lowest pressure, 29.64, at Block Island, R. I. Precipitation was general throughout the Ohio Valley, the Lake region, the middle Atlantic and New England states during the passage of this low area.

VIII.—This storm apparently advanced from the Pacific Ocean to the coast of Washington Territory, where it was central on the morning of the 23d. It moved across the continent in a direction slightly to the south of east until it reached the

Atlantic Ocean, after which it traveled to the northeast along the coast of New England and passed beyond the Maritime Provinces on the morning of the 27th. It was attended by light rains on the Pacific coast during the 23d, and by a decidedly warm wave over the northern and middle slopes of the Rocky Mountains and the Missouri Valley on the 24th, during which the rise in temperature was from 30° to 50° in twenty-four hours, with fair weather in all regions covered by the area on that date. On the morning of the 25th the storm was central over the Lakes, when light snow had set in, which during the day became general over the Ohio Valley, middle Atlantic, and New England states. The pressure at the centre began to decline rapidly, and when last observed it was 28.58 at Chatham, N. B. Violent gales prevailed on the middle Atlantic and New England coasts from midnight of the 25th till the morning of the 28th, the maximum velocity in many cases reaching sixty miles per hour.

IX.—This area of low pressure was first observed central over Washington Territory at 3 p. m. of the 25th. It moved in a direction slightly to the north of east, then to the southeast, and disappeared over Iowa, Illinois, and Missouri after 10 p. m. of the 26th, by a gradual increase of pressure. It was attended by fair weather and high temperatures, excepting on the north Pacific coast, where rains occurred.

X.—The approach of this low area was indicated by low readings of barometers over Manitoba, beginning on the morning of the 27th. The centre was first located to the north of Dakota at midnight of the 29th. It moved to the southeast with increasing pressure, attended by light winds and fair weather, passing to the ocean from the coasts of Virginia and North Carolina on the morning of the 31st.

NORTH ATLANTIC STORMS FOR JANUARY, 1888.

[Pressure in inches and millimetres; wind-force by Beaufort scale.]

The paths of the depressions that appeared over the north Atlantic Ocean during January, 1888, have been determined from international simultaneous observations by captains of ocean steamships and sailing vessels, received through the co-operation of the Hydrographic Office, Navy Department, and the "New York Herald Weather Service."

Nine depression are traced, of which six advanced eastward from the American continent north of the fortieth parallel; one developed over mid-ocean between the fortieth and forty-fifth parallels and moved east-northeast to the British Isles; one is given an approximated path from the vicinity of the Azores southwestward to the thirty-ninth meridian, and thence northward, and one passed south of east over the British Isles from the vicinity of the sixtieth parallel. With the exception of numbers 3, 6, and 7, the depressions pursued normal paths.

In January, 1887, twelve depressions were traced, of which seven passed northeastward over or near Newfoundland; four first appeared over mid-ocean, and one developed off the east coast of the United States. The depressions pursued east-northeast to northeast paths, and, being rather evenly distributed throughout the month, with tracks, as a rule, confined to territory north of the fiftieth parallel, caused a continuation of strong westerly gales in the trans-Atlantic routes.

In January, 1888, the depressions traced corresponded closely in number with the January average, and their passage was unattended by disturbances of unseasonable severity. The region of greatest storm frequency extended east-northeast from Newfoundland, and all depressions traced from the American coast disappeared to the northward of the region of observation between the twentieth and fortieth meridians. Two well-defined depressions advanced from the ocean over the British Isles, and two developed west of the Azores.

The month opened with an area of low pressure central north-west of Ireland, and moderate to fresh gales along the trans-Atlantic tracks to the Grand Banks. To the southward of Nova Scotia barometric maxima rising to about 30.50 (774.7)

were shown. During the 2d cyclonic disturbances continued over the British Isles, and unsettled weather and fresh to strong gales prevailed east of the fiftieth meridian. On the 3d two storms of marked energy, one of which had moved north-east over mid-ocean, and the other had advanced east over Newfoundland, dominated the weather conditions from coast to coast. By the 4th the barometric pressure had risen off the coasts of the United States, following the eastward movement of the depression central on the 3d off the Newfoundland coast. During the remainder of the first decade of the month there was a gradual increase in pressure over the British Isles, with fresh and brisk south to west winds; over mid-ocean barometric minima falling below 29.00 (736.6) attended the presence during the 5th and 6th of an area of low pressure central north of the fiftieth parallel; and from the 8th to the 10th, inclusive, storms of great violence were occasioned by a depression which moved northeast from Nova Scotia. During the second decade the barometer continued uniformly high over the British Isles. From the 15th to the 18th, inclusive, stormy weather prevailed west of the Azores, attending the presence in that region of a depression of considerable energy. The second decade was marked by the passage over Newfoundland and the western portion of the ocean of two depressions of great strength. During the last eleven days of the month no important disturbances occurred over the British Isles until the 31st, when the presence of a depression over the North Sea was indicated. Over mid-ocean moderate to fresh gales prevailed until the 26th, after which the pressure continued high with generally settled, fair weather. Over the western portion of the ocean stormy weather prevailed during the third decade, attending the passage of three depressions, two of which are traced over Newfoundland as ocean storms, and one, which advanced along the New England coast and over the Canadian Maritime Provinces during the 26th and 27th, is described under the heading "Areas of low pressure."

In the following descriptions of the depressions traced, posi-